REPORT

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"Theoretical and Experimental Studies
of the Underlying Processes and Techniques
of Low Pressure Measurement"

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IONIZATION GAUGE STUDIES IN LOW PRESSURE ATMOSPHERES

Studies reported here were suggested by George Newton of NASA to confirm the behaviour of NASA total pressure gauges while in flight. The problem concerned gauge errors caused by the different atmospheric compositions encountered in flight and the effect of these compositions on gauge surfaces. The research effort previously performed under NASA grant NsG 376 was altered to approach those aspects of this problem that were within the scope of present laboratory facilities. Briefly, these aspects are:

1. gauge pressure indication in gas mixtures;

2. surface ionization effects in the flight modulated B-A gauge;

3. relative senesitivities of gauges in different gases.

A vacuum system capable of low pressures and accommodation of the flight gauges, commercial B-A gauges, and Scheumann type gauges was constructed to do the above tests.

It was suggested by CSL that the omegatron-Klopfer ionization gauge properly displayed the properties of a monoenergetic ionizing device. With reference to an absolute pressure scale and acceptance of published ionization cross-section data, the omegatron could be used in a total pressure mode as a relative standard between different gases and mixtures of gases. Flight models of a modulated B-A gauge and a Redhead type gauge that had previously been extensively calibrated in nitrogen were obtained from NASA through George Newton and David Pelz. These gauges provide the reference to absolute pressure on the nitrogen scale and are the principal subjects of the proposed study in the atmospheres and pressure ranges agreed upon with NASA.

With bias to achieve total ion collection and a monoenergetic electron beam, the omegatron in a total pressure mode should display sensitivities to

gases that are in the same ratio as the ionization cross sections for those gases. To illustrate this, an I^+/I^- versus electron beam energy plot (holding constant pressure in a pure atmosphere with constant ionization path length and constant ion collection efficiency) would be a relative ionization cross-section curve. Such a curve is perturbed by secondary electrons which are emitted from metal surfaces-- e.g., the electron collector-- and increase the ion yield, shifting the electron energy scale, and thus distort the cross-section (sensitivity) curve. Figure 1 illustrates data taken at constant filament emission using 200 V electrons in argon. Ideally, $I^+/I-$ is a constant. However, as the electron collector potential approaches that of the preceding element, secondary electrons proceed back along the beam path (confined by a magnetic field) causing additional ionization. The bottom curve shows the effective decrease in electron current to the electron collector. This is accompanied by increases in electron current to elements further back down the path. The top curve, in effect, shows the variation in sensitivity as a function of electron collector voltage. This could account for omegatron sensitivity variation with electron collector potential and reported sensitivity ratios differing from ionization cross-section ratios.

A device similar to an omegatron, but with additional features for total ion collection and entrapment of secondary electrons, was constructed to permit ionization by a monoenergetic electron beam. It displays sensitivities to gases in the same ratio as the ionization cross section for those gases. Normalized I^+/I^- versus electron beam energy curves are shown in Figures 2 and 3 along with normalized total ionization cross-section curves.[1] The curves were taken at constant pressure and are for electron beam confining fields of 600 and 3500 gauss. The higher magnetic field crossed with the ion drawout electric field effectively changes the collected ion current. To

overcome this problem an electromagnet was constructed, permitting the device to be used either as a definitive total pressure apparatus or as an omegatron type of partial pressure analyzer. The latter mode of operation requires the higher magnetic field for resolution.

Although there is no attempt to relate the CSL device to any absolute pressure scale, Figures 4 and 5 show the device to be linear in argon and helium, respectively, in comparison to an ordinary B-A gauge. Data taken at approximately 1×10^{-10} Torr in this system indicates that x-ray currents caused by electrons striking ionizing region apertures will be well below the ion currents in pressure regions of interest. In the partial pressure mode, no attempt was made to achieve high resolution since simple gas mixtures are involved.

At this time:

1. The system has been constructed and functions well.

2. All gauges have been installed.

3. The measuring instruments are properly calibrated.

4. The CSL device functions in its partial pressure and total pressure modes.

5. Preliminary sensitivity runs have been made in noble gas atmospheres.

6. A program is being written for the CDC 1604 computer at CSL to handle the data reduction.

Surface Physics

Studies on adsorption and desorption of H_2, N_2, and CO from polycrystalline, (111), and (110) tungsten have been completed. This work has been written as a thesis by G. G. Tibbetts.

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[1] Rapp, Englander-Golden, J. Chem. Phys. $\underline{43}$, 1464 (1965).
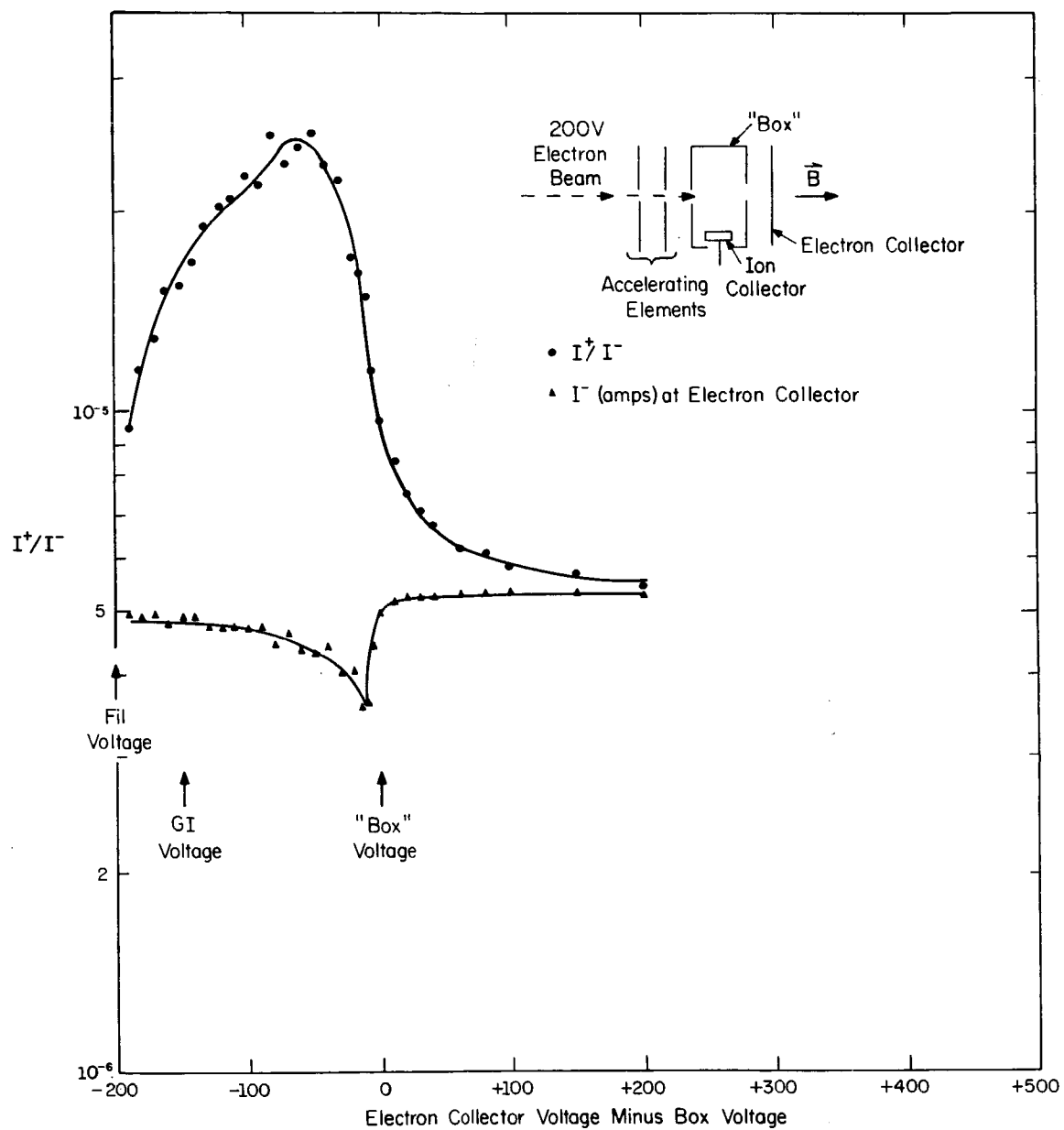
Figure 1. The effect upon omegatron behaviour of secondary electron emission from the electron collector.
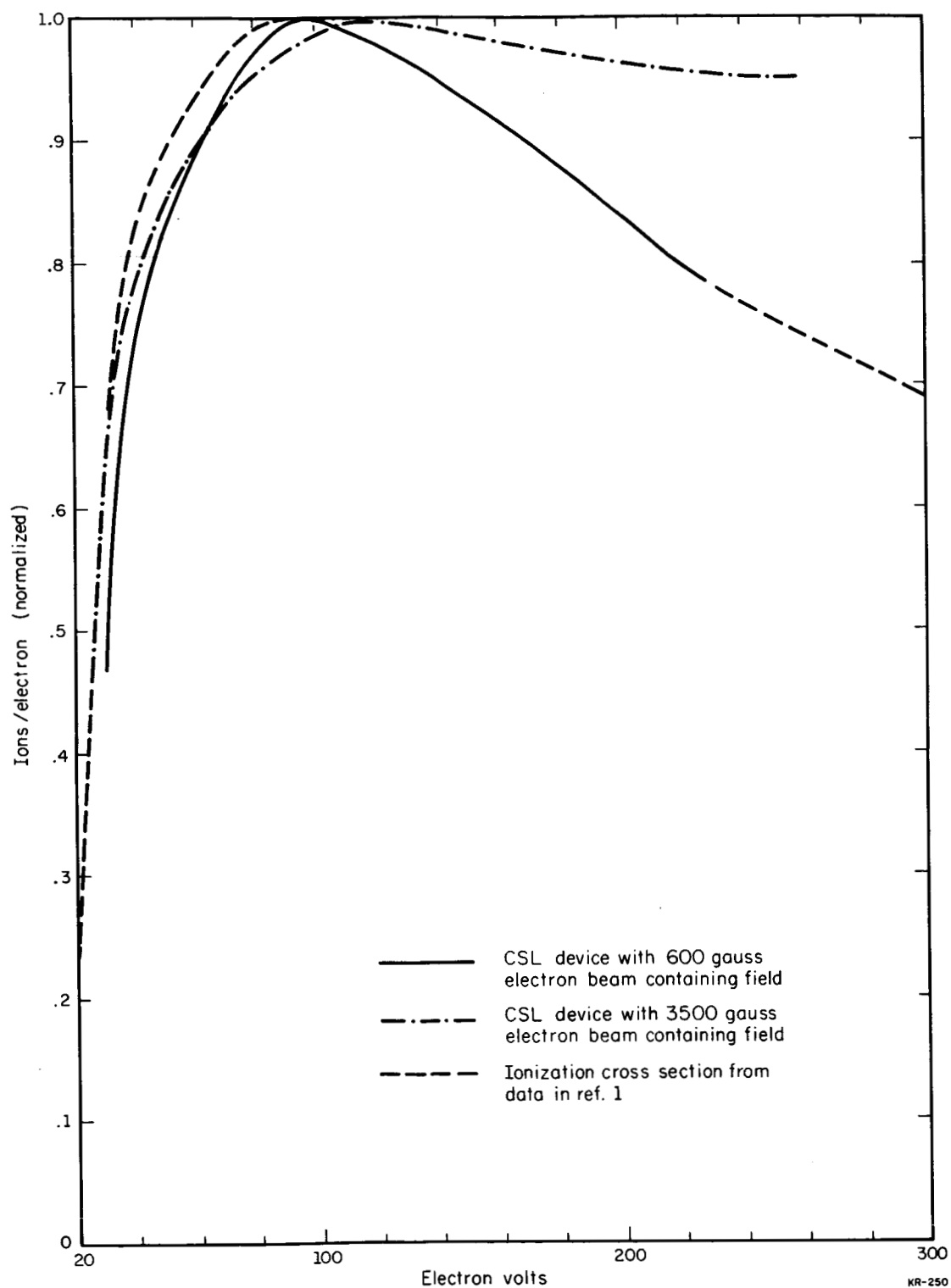
Figure 2.   Argon ions per ionizing electron (normalized) versus ionizing
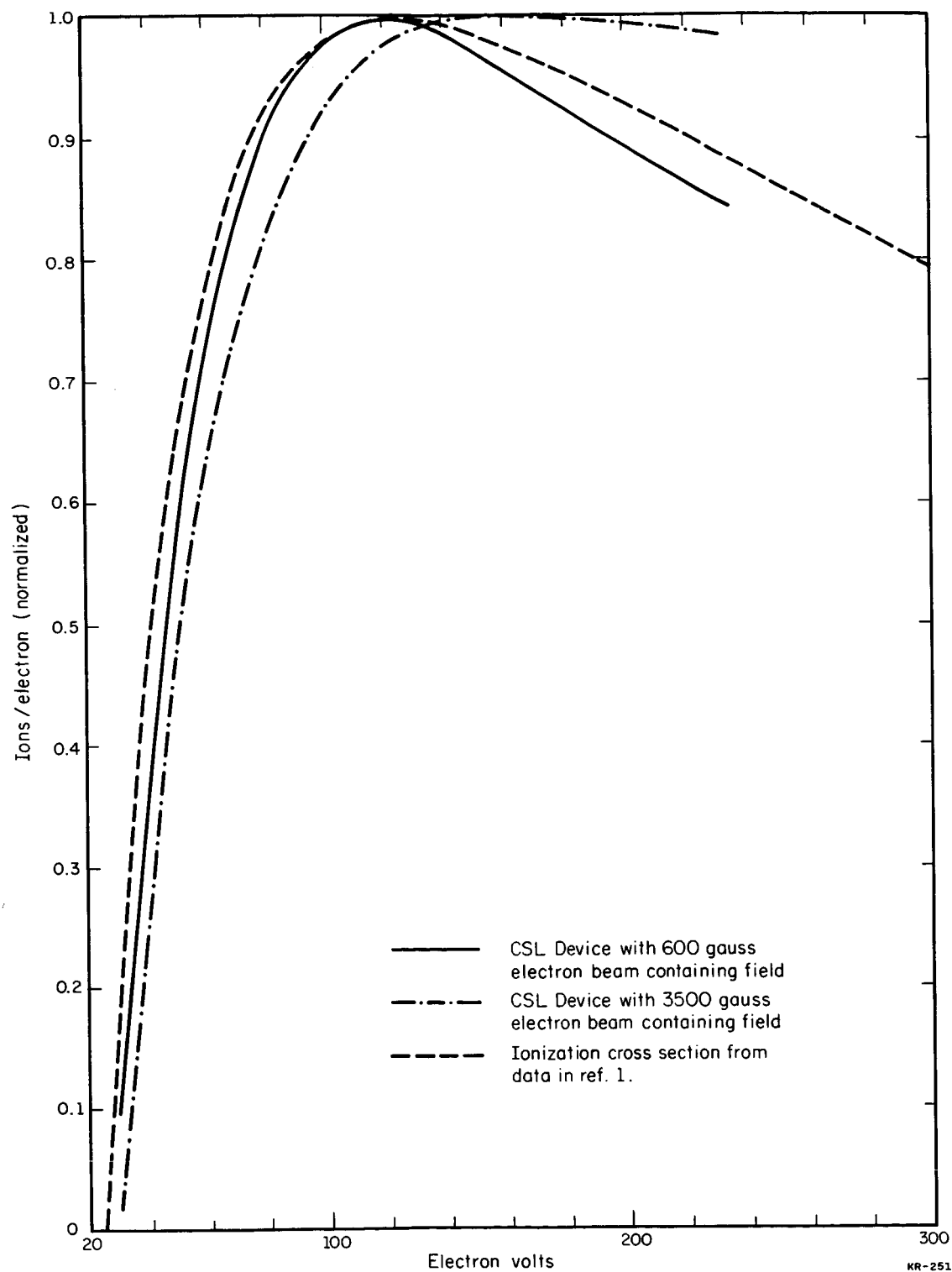electron energy.

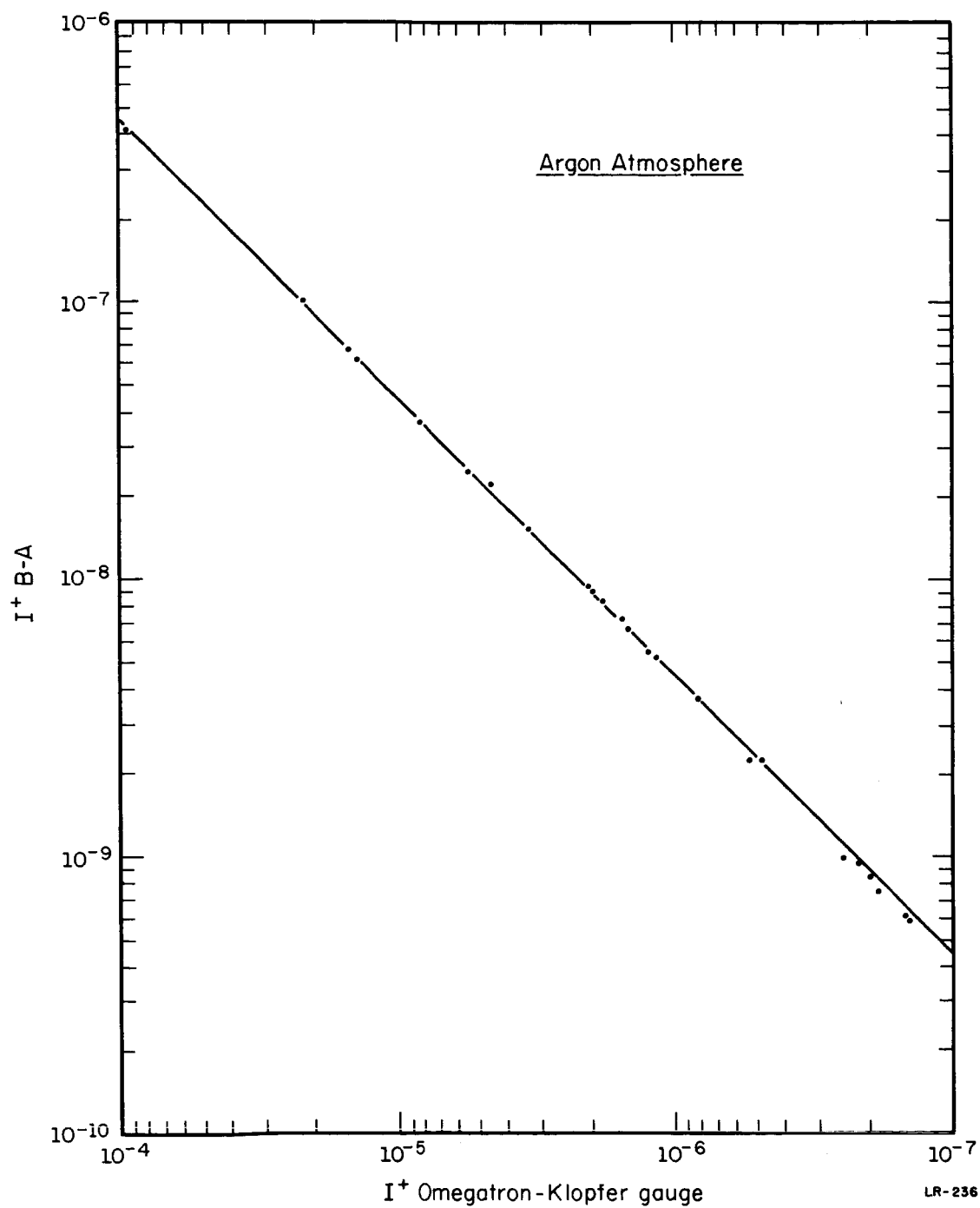Figure 3. Helium ions per ionizing electron (normalized) versus ionizing
electron energy.

Figure 4. B-A gauge ion current versus omegatron-Klopfer gauge ion current in argon using constant emission currents.
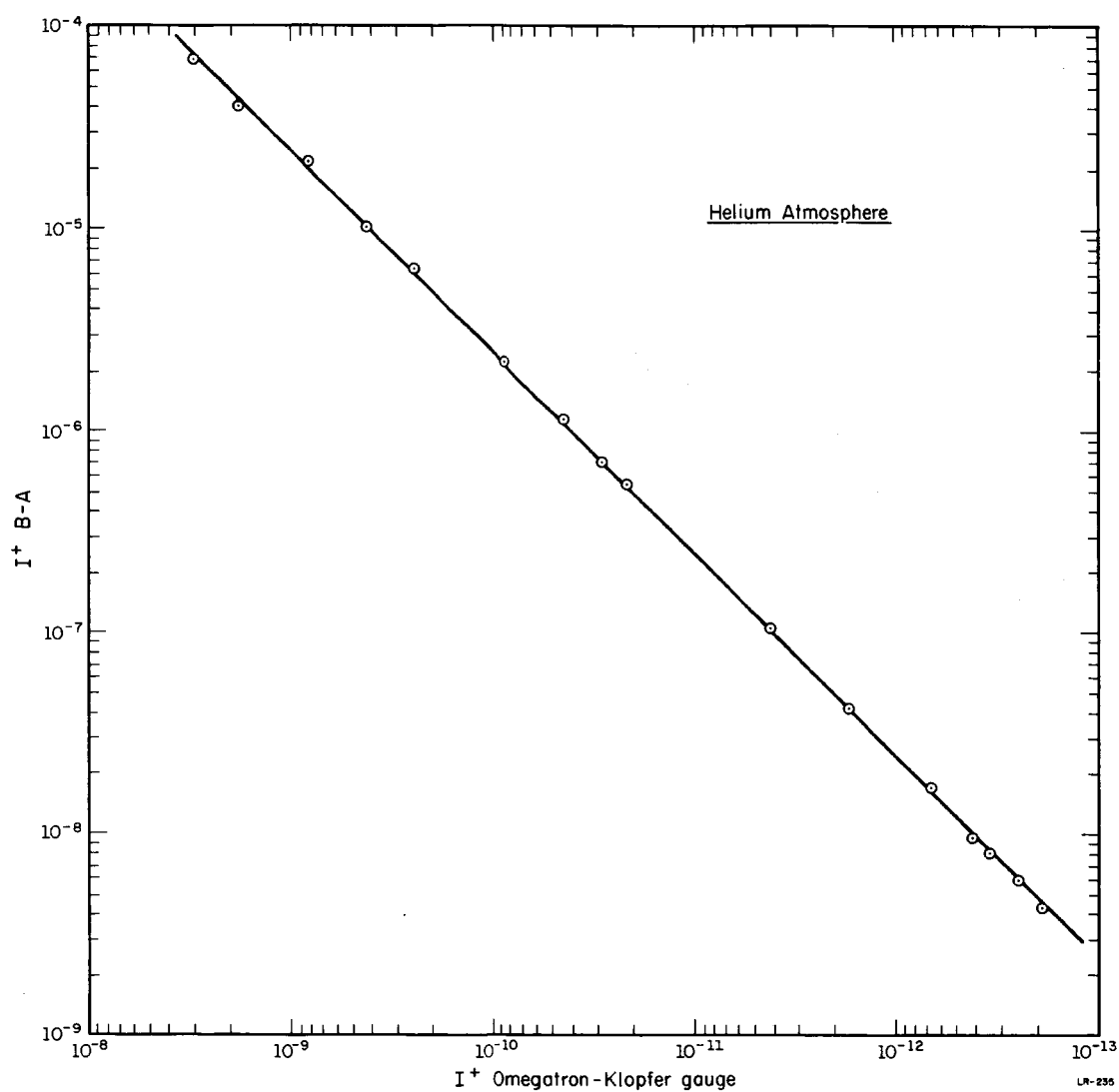
Figure 5. B-A gauge ion current versus omegatron-Klopfer gauge ion current in helium using constant emission currents.